Public debt sustainability: Debt arithmetic for Greece and some clarifications*

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Abstract

This note evaluates some standard criteria typically used to judge public debt sustainability and goes through a simple public debt arithmetic for the case of Greece.

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1 Motivation and main results

For the private sector to be willing to hold public debt, especially in the longer term, it must be confident that the government will meet its debt obligations and repay its debt in real terms. In this case, public debt is believed to be sustainable or, equivalently, the government is solvent. By contrast, if public debt sustainability is believed to be violated,[1] sovereign risk premia emerge and nominal interest rates start rising reflecting the fear of default on public debt. If this happens, it leads to vicious cycles of debt and recession. In this case, policymakers have no choice but to bring public debt down by using "conventional" and "unconventional" measures. The former include drastic spending cuts and tax rises, while unconventional measures can include unexpectedly high inflation that erodes the inherited real debt burden, wealth taxes that work like retroactive income taxes, asset confiscation, default on debt obligations which can take place orderly or one-sided and so disorderly, etc. All these measures have been used historically (see e.g. the book by Dornbusch and Draghi (1990) which also refers to the Greek case after WWI). Such fiscal austerity measures make things worse in the short term but may put the economy on a better path later on, although this depends on a number of factors.[2] The Greek sovereign debt crisis in the 2010s is a classic example of the above.

Public debt sustainability is therefore a necessary condition for macroeconomic stability which, in turn, is a prerequisite for economic growth and the financing of social policies. But how do we judge public debt sustainability? There are several approaches to this (see e.g. D' Erasmo et al (2016) for a nice review). The most common one, at least in policy reports and public debates, is based on the inter-temporal government budget constraint (IGBC). For example, the EU's fiscal sustainability indicators S1 and S2 are based on the IGBC (see e.g. European Commission (2022a, Annex A5)). Recommendations of the European Commission for the Greek public finances are also based on the IGBC (see e.g. European Commission (2022b)). We therefore find it natural to start with this.[3]

We will first clarify the conditions under which one can use the IGBC as a tool to judge public debt sustainability. Then, using the IGBC and working as typically in the policy literature, we calculate the primary fiscal surplus required

[1] As Jones (2008, chapter 13.5) points out, there is no magic level of the debt to GDP ratio that triggers such a calamity. The level depends on a number of economic and political fundamentals.

[2] For fiscal austerity, see e.g. the book by Alesina et al (2019). Philippopoulos et al (2017) quantify the role of the fiscal policy mix in case of debt consolidation and fiscal austerity. As they show, a damage-minimizing mix is the one in which we use fiscal instruments with small multipliers to bring public debt down and - once public debt has been brought down - we allow fiscal instruments with large multipliers to take advantage of the fiscal space created; the anticipation of the latter shapes incentives and may mitigate the recessionary effects even in the short term. But, as it happens with all policy reforms, it is important to take into account public trust, political support and distributional implications.

[3] For non-technical papers on public debt sustainability in the US and the EU, see e.g. Eichengreen (2022) and Schucknecht (2022) respectively. Related policy reports and papers on Greece are reported below.

for sustainability in the case of Greece. Our solutions below are between 1.7% and 3.4% as a percentage of GDP on average in each year over time for the next 35 years. Notably these numbers are within the ranges provided by the European Commission (2022b). Nevertheless, as is widely recognized, we should keep in mind that solutions like these depend heavily on the assumed difference between the real interest rate on sovereign bonds and the economy's growth rate, as well as on the assumed value of the debt to GDP ratio at the end of the time horizon studied.

In turn, building upon the above, we will make two methodological points. We will first argue that these calculations do not take account of the obligations of Greece to EU institutions - specifically, that the outstanding debt to ESM, EFSF, etc, from the three official fiscal bailouts of the previous decade amounting to around 250 billion euros, has been agreed to be repaid by around 2070. Once this is taken into account, the required fiscal surplus is higher than that implied by the standard calculations like those reported above. This is because when there are debt repayment deadlines as in the case of Greece, the primary fiscal surplus should adjust, not only to the differential between the real interest rate on sovereign bonds and the economy's growth rate as in the standard case, but also to the extra expenditures due to repayment of the EU debt. In the case of Greece, our calculations imply that, other things equal, this increases the required surplus by around 0.5 percentage point on average in each year over time.[4] Note that all this happens even if the EU debt is paid back at policy interest rates which are lower than the market ones. Actually, our calculations show that, other things equal, had the interest rate on the EU debt been the same as the market one, the required primary fiscal surplus would have been considerably higher (around 1.7 percentage points higher on average in each year over time). Our second methodological point will be that by relying on a single equation only, like the IGBC, one can get indicative results only. This is because the relationship between the real interest rate and the economy's growth rate, as well as the primary fiscal balance, are all endogenous variables depending on a number of factors including the level of public debt itself (see also e.g. D'Erasmo et al (2016)); the use of structural macroeconomic models is thus necessary to avoid the so-called Lucas critique.

2 Inter-temporal government budget constraint (IGBC)

According to the criterion of the IGBC, the public debt is sustainable when it is believed that the outstanding debt burden does not exceed the present discounted value of expected future fiscal surpluses, where the latter are tax

[4] If we add this 0.5 percentage point to the numbers mentioned above (i.e., 1.7%-3.4%), the size of the required primary fiscal surplus gets demanding, especially if we recall that during the last 20 years, Greece has had primary fiscal deficits, rather than surpluses, even during years of positive growth rates (the exceptions were in 2014 and 2016-2019). For data, see e.g. European Commission (2022c).

revenues minus public spending plus transfers from the central bank (CB) to its government. We will first formalize this argument and then provide numerical examples.

The within-period government budget constraint is (see e.g. Walsh (2017, chapter 4)):

$$G_t + i_t B_{t-1} \equiv (B_t - B_{t-1}) + T_t + N_t \tag{1}$$

where G_t is total government spending except interest payments, T_t is total tax revenues, B_t is the end-of-period total public debt, N_t is transfers from the CB to its government (if any) and i_t is the nominal interest rate on outstanding one-period bonds, B_{t-1}. All variables are written in nominal terms. Notice that for simplicity we assume bonds with one period maturity.

If we express nominal quantities as shares of nominal GDP, we have:

$$\frac{B_t}{Y_t} \equiv R_t \frac{B_{t-1}}{Y_{t-1}} + \left(\frac{G_t}{Y_t} - \frac{T_t}{Y_t} - \frac{N_t}{Y_t} \right)$$

where $R_t \equiv \frac{1+i_t}{(1+\pi_t)(1+\gamma_t)}$, $\pi_t \equiv \frac{p_t - p_{t-1}}{p_{t-1}}$ is the inflation rate and $\gamma_t \equiv \frac{y_t - y_{t-1}}{y_{t-1}}$ is the growth rate of real GDP.[5]

In a shorter notation, we have:

$$b_t \equiv R_t b_{t-1} + d_t \equiv R_t b_{t-1} - s_t \tag{2}$$

where $b_t \equiv \frac{B_t}{Y_t}$ is the end-of-period public debt to GDP ratio, $b_{t-1} \equiv \frac{B_{t-1}}{Y_{t-1}}$ is the beginning-of-period public debt to GDP ratio and $d_t \equiv \left(\frac{G_t}{Y_t} - \frac{T_t}{Y_t} - \frac{N_t}{Y_t} \right)$ is the primary fiscal deficit as share of GDP or, symmetrically, $s_t \equiv -d_t \equiv \left(\frac{T_t}{Y_t} + \frac{N_t}{Y_t} - \frac{G_t}{Y_t} \right)$ is the primary fiscal surplus.

By repeated forward substitutions,[6] we get (for notational simplicity, we assume that $R_t \equiv R$ remains constant over time):

$$b_{t-1} \equiv \frac{1}{R} \sum_{i=0}^{T} \left(\frac{1}{R} \right)^i s_{t+i} + \left(\frac{1}{R} \right)^{T+1} b_{t+T} \tag{3}$$

Equation (3) implies that the current liabilities are equal to the present discounted value of expected future fiscal surpluses plus the discounted value of end-of-horizon debt.

To the extent that $\frac{1}{R} < 1$ or $R > 1$ so that the summation is bounded and assuming that there is a finite terminal value for b_{t+T} (see the next section below for details on these two critical assumptions), equation (3) simplifies to (for notational simplicity, we assume that $s_t \equiv s$ is also constant over time):

$$b_{t-1} \equiv \frac{s}{R} \frac{1 - \left(\frac{1}{R}\right)^{T+1}}{1 - \frac{1}{R}} + \left(\frac{1}{R} \right)^{T+1} b_{t+T} \tag{4}$$

[5] Appropximately (around $i = \pi = \gamma \equiv 0$), $R_t \equiv \frac{1+i_t}{(1+\pi_t)(1+\gamma_t)} \cong 1 + i_t - \pi_t - \gamma_t$, where $i_t - \pi_t$ is the usual definition for the real interest rate.

[6] See e.g. Sargent (1987, chapter IX) and Wickens (2008, sections 5.4.3 and 5.4.4). Following these authors, Appendix A below provides a step-by-step solution.

Our understanding is that this is the equation that most policy reports use to evaluate public debt sustainability (see e.g. the European Commission's fiscal sustainability indicators S1 and S2 in European Commission (2020a, Annex A5)).

Unpleasant debt arithmetic and the EC's 2022 Report on Greece To see what equation (4) implies, say that the outstanding public debt to GDP ratio is 171% as was the case in Greece at the end of 2022. Also let us assume that the nominal interest rate is 4%, the inflation rate is 2%, so that the real interest rate is 2%, the growth rate of real GDP is 1%, so that $R = 1.01 > 1$, and that we consider a time horizon of say 35 years, i.e. $T = 35$, at the end of which the public debt ratio is simply set equal to its starting value, $b_{t+T} \equiv b_{t-1} = 1.71$. Then, equation (4) gives $s \cong 0.017$. In other words, using the simple IGBC in (4) and according to this numerical scenario, public debt sustainability requires a primary annual surplus of 1.7% on average over the coming 35 years. If, on the other hand, we assume that, at the end of the 35 years, the public debt ratio is lower, say 100% of GDP, then, other things equal, $s \cong 0.034$. In other words, according to this more ambitious scenario where the end-of-horizon debt is much lower than the one in the current data, the average surplus should be 3.4%. Note that these numbers are close to those of the European Commission. The latter reports numbers between 1.4% (under a relatively optimistic scenario about the gap between the real interest rate and the growth rate) and 3.1% (under a relatively pessimistic scenario about the same gap) in the European Commission's Post Programme Surveillance Report on Greece published in Autumn 2022.

3 A closer look at equation (2) and when we can use the IGBC

Let us now revisit equation (2) and have a closer look. To the extent that R_t and d_t are exogenous, this is a standard first-order linear difference equation in the path of the public debt to GDP ratio, b_t. Thus, we can typically distinguish two cases (see e.g. Sargent (1987, chapter IX) and Wickens (2008, chapter 5)).

Dynamically stable case If $R < 1$, equation (2) is stable. A model that satisfies this condition is said to be stationary. In this case, stability implies that the government can even run permanent deficits and eventually these deficits can lead to a positive but constant public debt. As Blanchard (2019) states, in this case, the government can roll over its debt, issuing new debt to pay for the interest, without the need to cut spending or raise taxes in the future (see the numerical example below). To put the same thing differently, public debt has no fiscal cost. Note however that, in practice, even if public debt can remain finite, there might be fears of default if this finite public debt ratio is considered to be "too" high. This can perhaps justify upper limits on the debt-to-GDP ratio like those of the Stability and Growth Pact in the EU (see Wickens (2008, chapter 5.4.2) and Blanchard (2019) for the implications of the stable case).

In this stable case, we solve the above difference equation backwards. By repeated backward substitutions,[7] we get (as above, we assume that R_t and d_t remain constant over time):

$$b_t \equiv d \sum_{i=0}^{t-1} R^i + R^t b_0 \tag{5}$$

where b_0 is the initial debt to GDP ratio.

To the extent that $R < 1$, equation (5) simplifies to:

$$b_t \equiv d \left(\frac{1 - R^t}{1 - R} \right) + R^t b_0 \tag{6}$$

Notice that, in the long run, since $R < 1$, this gives $b(1 - R) = d$, which defines what long-run debt will be for a given primary deficit or vice versa. See D' Erasmo et al (2016, section 2.1) for details and a critique of analyses that focus on long-run implications only ignoring transition dynamics and stability.

Pleasant debt arithmetic and Greece in the year 2022 Say that b_{t-1} is 193% of GDP, the nominal interest rate on outstanding debt, i_t, is 2%, the inflation rate, π_t, is 10% and the real GDP growth rate, γ_t, is 4%. Let us also assume a primary deficit of around 2% of GDP. These numbers are very close to the actual Greek data in the year 2022. Then, equation (6) above implies that at the end of 2022 the public debt ratio would be around 175%, which is substantially below the starting value of 193% and, actually, is close to the data (see European Commission (2022c)). That is, even with a fiscal deficit, the debt to GDP ratio has decreased over time. Note that, in this example, this happens mainly because inflation erodes the real burden of outstanding public debt and this leads to a fall in the end-of-period public debt to GDP ratio. As already mentioned above, this has been one of the classic ways to reduce public debt burdens and hence public debt ratios in the world history of debt (see e.g. Dornbusch and Draghi (1990)). But, as is widely recognized, this is a short-term resolution only to debt stabilization. In addition to the standard redistributive and aggregate costs associated with inflation, high inflation also means that the government will sooner or later have to make concessions. The latter typically include a mix of rising interest rate premia on long-term bonds, a shift to shorter maturities and the issuance of indexed bonds (of course, all this applies to newly issued bonds). If such things occur, sooner or later, the burden of adjustment will shift to higher taxes and/or spending cuts.

Dynamically unstable case Now say that $R > 1$, and so that public debt is not stationary meaning that, given d_t, its path is explosive over time. It is worth

[7] See e.g. Sargent (1987, chapter IX) and Wickens (2008, section 5.4.1). Following these authors, Appendix B below provides a step-by-step solution.

pointing out here that this case, namely, the case in which the real interest rate exceeds the economy's real growth rate, is rather common in the historic data.[8] Well known exceptions include the 2010s thanks to the big monetary expansion adopted by most central banks to counter the global financial crisis and the current period, since the beginning of 2022, due to soaring energy prices and high inflation as a result of Russia's invasion of Ukraine.

How can we restore stability and hence sustainability in the case in which equation (2) is unstable so that public debt is explosive over time and public debt sustainability is violated? There are two ways.

First, we can introduce a feedback fiscal policy rule according to which a fiscal instrument reacts to outstanding public debt so that the "effective" coefficient on outstanding debt becomes less than one. This is the most common way in the academic literature (see e.g. D'Erasmo et al (2016)). Formally, if d_t can be treated as a policy instrument, it is now contingent on outstanding debt, say $d_t \equiv -\mu b_{t-1}$, where $\mu > 0$ is a feedback policy coefficient which is set high enough so as $(R - \mu) < 1$ and hence equation (2) becomes stable. D'Erasmo et al (2016) provide estimates of fiscal reaction function like this for a number of countries; as expected, they find that debt stabilization reactions become much weaker when post-2008 are added to the sample. For fiscal reaction functions in EU countries, see European Commission (2015, part IV).

Second, we can work with the inter-temporal government budget constraint (IGBC) as we did in the previous section, which means that we solve equation (2) forward. As we saw above, this gives stability since $\frac{1}{R} < 1$ in equation (3). However, it is worth adding a word of caution before we move on. To exclude Ponzi-type games as the time horizon gets larger and larger,[9] we need to pin down the value of public debt at some point in time in the future (see e.g. equation (4) above). Usually, this is done by imposing the terminal condition $\lim_{T\to\infty} \left(\frac{1}{R}\right)^{T+1} b_{t+T} = 0$.[10] This looks to be innocent at first sight since $\frac{1}{R} < 1$, but this presupposes that b_{t+T} is finite. If however the latter is thought of as a rational bubble, its expected value is explosive over time.[11] In other words, debt sustainability with the IGBC – meaning that future primary surpluses must be large enough to meet the current debt obligations – also requires that we are willing to assume the bubble away, e.g. to set $\lim_{T\to\infty} \left(\frac{1}{R}\right)^{T+1} b_{t+T} = 0$, which means that we restrict ourselves to the so-called fundamental solution.

[8] See e.g. Malley and Philippopoulos (2022) for the US and Dimakopoulou et al (2022) for Greece.

[9] A Ponzi game is a pyramid in which new borrowing is used to pay existing obligations. In our case, this terminal condition rules out funding debt interest payments by issuing new debt. See Wickens (2008, section 5.4.3).

[10] See also European Commission (2022a, Annex A5).

[11] See e.g. Blanchard and Fischer (1989, chapter 5) for a proof and the literature on multiple self-fulfilling equilibria. See also Sargent (1987, chapter IX, p. 181).

4 Some more careful debt arithmetic and the case of Greece

The above may be helpful to educate ourselves with the standard methodology used in policy circles to evaluate debt sustainability but, in the case of Greece, there is a peculiarity because a large part of the Greek public debt is in the hands of non-market EU institutions (like the ESM, EFSF, etc) as a result of the three official fiscal bailouts in the 2010s amounting to around 290 billion euros, and the obligation is that all this has to be paid back between 2060 and 2070 (by the year 2060 for ESM loans and by 2070 for EFSF loans). In this section, we will attempt to model this in a simple way and try to quantify the average fiscal surplus needed in this case. Given the complexity of the structure of Greek public debt, our calculations will be indicative only. Also note that we keep working with the government budget constraint only, although this will be critically assessed in the next section.

Decomposing the Greek public debt into that held by private agents/banks and that held by non-market EU institutions, we rewrite (2) as:

$$b_t^p + b_t^{eu} \equiv R_t^p b_{t-1}^p + R_t^{eu} b_{t-1}^{eu} - s_t \qquad (7)$$

where the superscripts p and eu refer to public debt owed to private agents/banks and non-market EU institutions respectively and s_t denotes the total primary fiscal surplus (we again assume one period debt maturity for simplicity).

We will work in steps. We will first calculate the average over time fiscal surplus needed to pay back the debt to the EU in, say, 35 years, and in turn check what this implies for the other part of the debt (namely, the private one) and for the total primary fiscal surplus.

Regarding the fraction of Greek public debt in the hands of non-market EU institutions this has been estimated to be at least 70% of the total Greek public debt (see Dimakopoulou et al (2022)). If we assume that the non-market nominal interest on this part of the debt is 1%, and, as assumed above, inflation is 2% and the growth rate is 1%, and that all of them remain constant over time, this implies $R_t^{eu} = 1 + 0.01 - 0.02 - 0.01 = 0.98 < 1$, which in turn means that the associated difference equation, $b_t^{eu} \equiv R_t^{eu} b_{t-1}^{eu} - s_t^{eu}$, is stable. Thus, we can use equation (6) above. Setting $b_t^{eu} = 0.7x1.71$ and assuming that after 35 years this part of debt is fully repaid, equation (5) implies that, other things equal, this requires an average primary fiscal surplus of $s_t^{eu} \cong 0.023$ or 2.3% over the next 35 years.[12] Before we move on, it is worth examining what s_t^{eu} would be in the counter-factual case in which the nominal interest rate on the EU debt were the market one. In particular, we examine what happens if $b_t^{eu} \equiv R_t^{eu} b_{t-1}^{eu} - s_t^{eu}$, where, by using the same numbers as in the previous section, $R_t^{eu} = 1 + 0.04 - 0.02 - 0.01 = 1.01 > 1$. In this case, we have to use equation (4) which gives $s_t^{eu} \cong 0.04$ or 4%.[13] This is much higher than 2.3%.

[12] Thus, s^{eu} solves $0 = -s^{eu}\left(\frac{1-0.98^{35}}{1-0.98}\right) + \left(0.98^{35}x0.7x1.71\right)$.

[13] Thus, now s^{eu} solves $0.7x1.71 = -\frac{s^{eu}}{1.01}\left(\frac{1-\left(\frac{1}{1.01}\right)^{36}}{1-\frac{1}{1.01}}\right) + 0$.

In turn, we plug this value of 0.023 as a constant term (denoted as a) on the expenditure side of equation (A.3) in Appendix A which is a generalization of equation (4) above. Thus, the associated difference equation is $b_t^p \equiv R_t^p b_{t-1}^p - s_t^p + 0.023$. Also as in the previous section, we first study the less ambitious scenario where the end-of-period private debt (which will also be the total public debt, since the EU public debt will have been repaid in 35 years) remains as it is today, namely, $b_t^p \equiv b_{t+T} \equiv 1.71$. Then, equation (A.3) implies $s_t^p \cong 0$.[14] In other words, the total primary fiscal surplus required for sustainability if the public debt after 35 years simply remains as it is today (namely, 171% of GDP) is or 2.3%, which should be compared to 1.7% in the experiment above which did not take into account the obligations of Greece to the EU institutions. If, on other hand, again as we did above, the public debt after 35 years is assumed to be 100% of GDP, the same calculations imply $s_t^p \cong 0.017$.[15] In other words, the total primary fiscal surplus required for sustainability in the more ambitious case in which the public debt after 35 years will be 100% of GDP, is $0.023 + 0.017 = 0.04$ or 4%, which should be compared to 3.4% in the experiment above which did not take into account the obligations of Greece to the EU institutions.

In sum, the primary fiscal surplus should be higher than that implied by standard-type calculations which do not take into account the obligations of the country to the EU, specifically, that the outstanding debt to ESM, EFSF, etc, has been agreed to be paid back by around 2070. This happens because, in the standard-type calculations found in most policy reports, the surplus needs to adjust merely to the differential between the real interest rate and the economy's growth rate (see sections 2 and 3 above). By contrast, when there are debt repayment deadlines like in the case of Greece, the surplus should adjust, not only to this differential but also to the extra expenditure due to repayment of the EU debt. This is a methodological issue which means that – irrespectively of the primary fiscal surplus implied by the standard calculations that unavoidably depend of the assumed values of the real interest rate and the economy's growth rate – the inclusion of these repayments increases the required surplus by around 0.5 percentage point on average over time. Note that all this happens even if the EU debt is paid back at policy interest rates which are lower that the market ones. Actually, our calculations have shown that had the interest rate on the EU debt been the same as the market one, the required primary fiscal surplus would have been considerably higher (around 1.7 percentage points higher on average over time).

[14] Thus, s^p solves $0.3x1.71 + \frac{0.023}{1.01}\left(\frac{1-\left(\frac{1}{1.01}\right)^{36}}{1-\frac{1}{1.01}}\right) = \frac{s^p}{1.01}\left(\frac{1-\left(\frac{1}{1.01}\right)^{36}}{1-\frac{1}{1.01}}\right) + 1.71\left(\frac{1}{1.01}\right)^{36}$.

[15] Thus, now s^p solves $0.3x1.71 + \frac{0.023}{1.01}\left(\frac{1-\left(\frac{1}{1.01}\right)^{36}}{1-\frac{1}{1.01}}\right) = \frac{s^p}{1.01}\left(\frac{1-\left(\frac{1}{1.01}\right)^{36}}{1-\frac{1}{1.01}}\right) + \left(\frac{1}{1.01}\right)^{36}$.

5 OK, but is it a good idea to rely on the government budget constraint only?

So far, following most policy reports, we have relied on the government budget constraint only. Since this is a single difference equation in public debt, the dynamics of public debt depend, by construction, on the relationship between the real interest rate and the economy's growth rate, as well as on the specification of the primary fiscal balance. All these three variables are treated as exogenous in this single equation analysis. Obviously, this is not satisfactory. Both the real interest rate and the growth rate depend on a number of factors including the level of public debt itself. There is also evidence that primary fiscal balance are correlated with macro variables and can vary over the business cycle either counter-cyclically (which further destabilizes the public finances) or pro-cyclically (which exerts a stabilizing effect on public finances).[16] A similar kind of criticism applies to fiscal reaction functions as a way of reducing the coefficient on outstanding debt in the single equation approach: when there is fiscal reaction, the behavior of agents changes and this affects the growth rate, the interest rate, the tax bases, etc. All this, as pointed out by D'Erasmo et al (2016), is a reflection of the Lucas critique.

In other words, a more reliable public debt sustainability analysis would require the use of structural macroeconomic models where these three key variables (the real interest rate on sovereign bonds, the economy's growth rate and the fiscal primary balances), plus other macro variables (like consumption, investment, current account balances, etc) that are strongly correlated with the three key ones, are all endogenous and so are jointly determined. There are many dynamic general (dis)equilibrium models of this type in the academic literature but also by researchers in the European Commission, the European Central Bank, the IMF, the Bank of Greece, etc. Examples, for the case of Greece, include Papageorgiou et al (2010), Papageorgiou (2014), Dellas et al (2017), Economides et al (2021, 2022) and Dimakopoulou et al (2022). To the best of our understanding, the message from this applied macroeconomic literature does not differ qualitatively from the simple calculations above. And this message can perhaps be summarized by two points: First, if a shock hits the Greek economy (even of a small magnitude), fiscal corrections of some type (spending cuts and/or tax rises) are necessary for dynamic stability. Second, with forward-looking agents, delaying such corrections can be costly even in the short term, especially if public trust is suddenly lost and nominal sovereign interest rates jump upward because of an "accident". We close with a final clarification. If, in practice, we do not observe any systematic reaction to public debt imbalances, then, quoting Leeper et al (2010) in their study for the US, a natural question to ask is "Why do forward-looking agents continue to purchase

[16] In Greece, for example, the data show that fiscal balances have been counter-cyclical most of the times, in the sense that in the 2000s, there were deficits and economic growth, while, in the 2010s, there were surpluses and recession. By contrast, in industrial countries, most of the times, they are pro-cyclical following the logic of Barro's tax-smoothing model. See e.g. D'Erasmo et al (2016).

bonds with relatively low interest rates and bond prices don't plummet?". The answer given by Leeper and his co-authors is that - to the extent that we want to maintain the assumption of rationality - agents believe that current inaction is temporary and it will be replaced by necessary policy corrections in the future. This is why expectations about the future, and what is signaled by policymakers in the present, are crucial.[17]

[17] See e.g. Bassetto and Miller (2022) for a recent model on how fiscal imbalances, inflation and information can be suddenly connected to each other.

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Appendices

Appendix A

Consider the linear difference equation in Y_t:

$$Y_t = RY_{t-1} + a + bX_t \tag{A.1}$$

where $R > 1$.

By repeated forward substitutions, we get:

$$Y_{t-1} = -\frac{a}{R}\left(1 + \frac{1}{R} + ... + \left(\frac{1}{R}\right)^T\right) - \frac{b}{R}\sum_{i=0}^{T}\left(\frac{1}{R}\right)^i X_{t+i} + \left(\frac{1}{R}\right)^{T+1} Y_{t+T}$$

or

$$Y_{t-1} = -\frac{a}{R}\left(\frac{1 - \left(\frac{1}{R}\right)^{T+1}}{1 - \frac{1}{R}}\right) - \frac{b}{R}\sum_{i=0}^{T}\left(\frac{1}{R}\right)^i X_{t+i} + \left(\frac{1}{R}\right)^{T+1} Y_{t+T} \tag{A.2}$$

which generalizes (3).

If we also assume that X is constant, we have:

$$Y_{t-1} = -\frac{a}{R}\left(\frac{1 - \left(\frac{1}{R}\right)^{T+1}}{1 - \frac{1}{R}}\right) - \frac{bX}{R}\left(\frac{1 - \left(\frac{1}{R}\right)^{T+1}}{1 - \frac{1}{R}}\right) + \left(\frac{1}{R}\right)^{T+1} Y_{t+T} \tag{A.3}$$

Appendix B

Again consider the linear difference equation in Y_t:

$$Y_t = RY_{t-1} + a + bX_t \tag{B.1}$$

except that now $R < 1$.

By repeated backward substitutions (see Sargent, 1987, p.180), we get:

$$Y_t = a\sum_{i=0}^{t-1} R^i + b\sum_{i=0}^{t-1} R^i X_{t-i} + R^t Y_0$$

where Y_0 is a given initial value.

Since $R < 1$, this is written as:

$$Y_{t-1} = \frac{a\left(1 - R^t\right)}{(1 - R)} + b\sum_{i=0}^{t-1} R^i X_{t-i} + R^t Y_0 \tag{B.2}$$

or if X remains constant, as:

$$Y_{t-1} = \frac{a\left(1 - R^t\right)}{(1 - R)} + \frac{bX\left(1 - R^t\right)}{(1 - R)} + R^t Y_0 \tag{B.3}$$

which generalizes (6). It is reduced to (6) for $a = 0$ and $b = 1$.